Chapter 5. Vegetation Condition and Trends

Overview of Probable Historical Changes in Distribution of Vegetation

The companion study to this report, *Historical Riparian Habitat Conditions of the San Joaquin River* (Jones & Stokes 1998), found a 28% reduction in riparian forest and scrub along the San Joaquin River and an 82% reduction in marsh and herbaceous riparian vegetation between 1937 and 1993, the most recent year of comprehensive aerial photographic coverage in the study area. During the same time span, a corresponding increase in agricultural development in the historical floodplain, urban expansion, expansion of sand and gravel mining, and reduction of river hydrology (baseflow and bankfull discharge frequency and duration) occurred. The aerial photomapping indicates that the most changes in cover type occurred between 1937 and 1957.

This section of this report supplements the results of the companion study (Jones & Stokes 1998) and adds further field-based interpretations of the maps and tables of existing riparian habitat contained in that study.

Subreach 1

In subreach 1, changes in total cover affecting riparian habitat were attributed primarily to expansion of mining, urban uses (e.g., golf courses), and vineyards. A structural and lateral change in riparian cover was the shift from riverwash bars and scrub-dominated vegetation in the active channel to alder-buttonwillow forest dominating the former gravel bars along the low-flow channel. This change is primarily attributed to altered hydrology, resulting in much lower energy gradients and infrequent channel scour in subreach 1.

Subreach 2

Changes in total cover in subreach 2 were attributed primarily to expansion of agricultural fields and vineyards, with a corresponding reduction in forest, scrub, and marsh vegetation. Reductions in flood frequency, scour potential, and wetting of the floodplain because of altered hydrology from Friant Dam and the flood bypass and levee system are likely to have accelerated the rate and extent of agricultural conversion of the riparian corridor in subreach 2.

Subreach 3

In subreach 3, a change in riparian succession took the form of a reduced extent of willow scrub and bare riverwash in the active channel, replacing them with a greater proportion of riparian forest along banks and on bars in the channel. Reduced scour resulting from much lower flood frequency probably caused this shift. A narrowing of the riparian corridor also occurred, primarily between 1937 and 1957, because middle to upper floodplain elevations were developed for agricultural uses (and some urban expansion after 1957 at Firebaugh).

Subreach 4A

Changes on subreach 4A were similar to changes observed on subreach 3. Agricultural conversion of floodplain surfaces is even more complete in this subreach, and in 4B downstream. The bordering riparian forest constitutes a relatively narrower feature of the river in 4A than in 3. Where the channel is subject to longer durations of no flow in 4A, some riparian scrub has reinvaded the low flow channel, occupying alternate sand bars within the steep channel banks.

Subreach 4B and 5

A narrowing of the riparian corridor is also observed along subreach 4B in addition to a decline in marsh areas along the channel and major sloughs west of the river and a gradual increase in dense riparian forest and scrub in a narrow corridor along the mainstem river.

In subreaches 4B and 5, direct conversion to agricultural and urban land cover was not a major factor in the reduction of riparian forest and marsh, probably because poor-quality soils and greater flood and sedimentation potential discouraged these uses on the broad floodplain and in basins bordering the river. Reduced hydrology, levee and ditch construction that isolated backwater ponds and sloughs, and draining of large marsh areas appear to be the primary factors in the reduced acreage of riparian-associated habitats. A very low rate of recolonization of riparian vegetation, which is attributed to infrequent inundation of floodplains and secondary sloughs and, possibly, higher concentrations of surface salinity, contributes to an overall gradual loss of woody cover as existing mature willow-oak woodlands decline because of age.

Current Pattern of Riparian Vegetation

Current Pattern of Riparian Vegetation Subreach 1 supports nearly continuous riparian vegetation, except where the channel has been disrupted by instream or captured wet pits; where there are wet pits, open water bordered by upland vegetation on steepened banks may dominate the river. In contrast, subreach 2 supports narrow but nearly continuous vegetation along the lower 7 miles to RM 212, but from there to RM 227.5 (near Gravelly Ford) vegetation is sparse or absent. Apparently healthy, mature trees (sycamore and cottonwood) occasionally dot the landscape within the levees in this subreach.

Nearly continuous riparian vegetation of various widths and cover types occurs in subreach 3 on at least one side of the channel, with several larger nodes (300–600 feet wide) of mature cottonwood forest or oak woodland/savanna.

In marked contrast to subreach 3 upstream of Sack Dam, subreach 4A is only sparsely vegetated, with the vegetation consisting of narrow strands or patches of mostly willow scrub or small potholes with marsh vegetation. In some areas, subreach 4A is completely devoid of woody cover. Subreach 4B upstream of Mariposa Slough supports a dense, nearly unbroken but narrow corridor of willow scrub or young mixed riparian on most of the remaining subreach, with occasional large gaps or patchiness in the canopy.

Subreaches 4B and 5 have a similar pattern of vegetation, although the width of open water in the channel is greater in subreach 5. Both subreaches are surrounded by large expanses of upland grassland with numerous inclusions of woody riparian vegetation within the arid floodplain disconnected from the mainstem river and concentrated in mostly dry secondary channels and depressions or old oxbows. Along the mainstem river, a relatively uniform pattern of patchy riparian canopy hugs the channel banks as large individual trees or clumps (primarily valley oak or black willow), with the understory consisting mostly of grassland. Vegetation shown in the 1938 aerial photographs exhibited a similar patchy pattern in subreaches 4B and 5, but with greater total woody cover, a higher proportion of mixed riparian vegetation relative to scrub, and large expanses of herbaceous riparian and marsh vegetation clustered along the river and sloughs. These are no longer present.

Forest Nodes and Connected Habitats

Several large nodes of high-density riparian forest and oak woodland occur in subreaches 1, 3, and 5; these nodes range from 20 to 75 acres, not including surrounding lower-density woody vegetation and undisturbed grassland. These large nodes of vegetation occur primarily along old channel oxbows or within meander bends and are sometimes associated with seasonal open water ponds and swales.

Good connectivity with adjacent watersheds and large habitats is found at the confluence of the San Joaquin River with the Merced River alluvial fan, where several secondary and former channels of the Merced River blend into the vast expanse of Great Valley Grassland State Park, Fremont Ford, and the confluence with Mud and Salt sloughs. A complex array of forest nodes and strands, savanna, and grassland with natural anabranched topography converges at this general location (RM 112 to RM 132). Although the managed wetlands of the San Luis Refuge border the floodplain of the San

Joaquin River in this area, poor habitat connectivity exists because of the parallel barriers of barren grassland, levees, and large canals (e.g., Island Canal C).

Although Bravel, Mariposa, Sand, and Lone Willow Sloughs closely parallel or are tributary to the San Joaquin River in subreaches 3, 4, and 5, poor connectivity exists because of the separation created by levees, canals, and cotton and alfalfa fields as well as the absence of riparian vegetation along these tributaries where the sloughs pass within the flood bypass levees and converge with the mainstem river. At Mendota Pool, the river is connected through open water to the managed wetlands of the Mendota Wildlife Area. However, the continuity of the wetlands complex with the riparian corridor above and below the dam is broken by discontinuous or narrow woody vegetation along the shoreline south of the dam, around Mendota Pool, and bordering the Kings River, and by several large canals with levees that connect to the pool from the west.

Upstream of Mendota Pool, no major tributaries or forested areas occur, except for habitats associated with large complexes of mining pits (active and inactive), some with ponds, marshes, and shoreline habitat, and the intermittent tributary of Little Dry Creek near Friant (e.g., Department of Fish and Game's Willow and Milburn Units). Continuity with the watershed of Little Dry Creek is interrupted by mining activity near the San Joaquin River, but a forested corridor exists along the creek at its confluence with the river. Connectivity of the river corridor with off-channel mine pit habitats varies greatly by location; some are well-connected by fingers of marsh and riparian vegetation bordering open water channels while others comprise a broken maze of bare upland separation walls or large expanses of open water with little shoreline habitat value. Secondary channels around "islands" in subreach 1 (e.g., Scout, Cobbs, Ledger Islands) are generally well connected with the main river corridor by well-developed canopies of oak woodland and riparian forest, but hydraulic connectivity with the high water channels under the canopy is diminished by lack of seasonal flow (because of reduced bankfull discharge frequency). Golf courses exist over several river miles and, although manicured landscapes, they provide a vegetated buffer to the high-density urban landscape on the terraces overlooking the river in subreach 1A.

Recruitment and Colonization

Patterns of recruitment and colonization vary greatly within the study area, as observed in late fall 1998. The greatest extent of cottonwood seedlings was found throughout subreach 2 in narrow rows along, and within 6 to 12 inches above, the low-flow water surface on sandy substrate or sandy-gravel substrate. This subreach is normally dry throughout most of the year, but temporarily augmented flows below Friant to compensate for a damaged riparian water diversion intake structure in subreach 1 (Landis pers. comm.) apparently resulted in prolonged baseflow in this subreach. Older saplings and young riparian scrub were not, however, present in subreach 2. Small clusters of cottonwood seedlings were also found on low gravel bars in subreach 1A and on moist silty-sand bars in subreach 5. Willow seedling clusters were found on isolated sandy-silt, bank-attached bars within the active channel in subreaches 4 and 5, sometimes mixed with cottonwood seedlings and herbaceous cover.

Saplings, primarily willow species, occurred sporadically in subreaches 2, 3, and 5 on low point bars and bank-attached alternate bars within the channel. Throughout the study area, seedlings and saplings in large or small isolated stands were rarely found more than 3 vertical feet above the low-flow water surface; one notable exception was a crop of cottonwood seedlings within a moist depression on an upper floodplain in subreach 3. Most seedlings and saplings occurred within one foot above the low-flow water surface on generally moist, depositional sand bars.

Even-aged stands of young trees and shrubs (scrub types) occurred on point bars, primarily in subreaches 1 and 3; these stands were dominated by sandbar willow in subreach 3 and willow-ash in subreach 1. Small, isolated stands of sycamore saplings were found in subreach 2. Old-growth cottonwood, sycamore, black willow, and valley oak woodland and savanna observed growing on upper floodplains or natural levees throughout the study area generally had an understory of upland grassland with little other understory development. Saplings or young trees were rare or absent on upper floodplain surfaces that otherwise supported mature woodland types.

Apparent Major Limiting Factors

Channel Hydraulics and Substrate Stability (Bed Scour)

Scour and transport of bank and bed material (sand and gravel) was evident throughout the study area during the field surveys (Chapter 4). Extensive channel bar formation and channel braiding is most acute in the sand bed–dominated subreach 2, but large expanses of sand waves on high bars and floodplains were also encountered in subreaches 1A and 5. Some evidence of uprooting and transport of trees and shrubs was observed in all subreaches, but the extent was considerably less than expected following a flood event of the magnitude of January 1997 (estimated at 60,000 cfs, which approaches the Corps-predicted 100-year discharge of 75,500 cfs). Loss of riparian vegetation as a result of hydraulic scour and river bank erosion appeared to be much less extensive on the San Joaquin River than on other Central Valley rivers in 1997 (e.g., Sacramento, American, Feather, Yuba, Cosumnes).

At least three factors may explain the relative stability of San Joaquin River vegetation:

- Comparison of maps prepared from aerial photographs (1938–1993) for the study of historical riparian habitat conditions (Jones & Stokes 1998) and of 1938 photographs to the 1914 surveys reveal that the San Joaquin River channel has moved little over the past 80 years other than shifts in the braided sand-channel network in subreach 2.

- ✦ Subreaches 2–4, especially lower subreach 2 and 4B, received only a fraction of the flood flow below Friant Dam, with the majority of the flow conveyed within the bypass system or exiting at numerous levee breaches in subreach 2.

- ✦ Estimated bankfull discharge and corresponding velocities at surveyed cross sections (Tables 3.3, 3.4, and 3.5) are 2–3 feet per second or less, which is within the normal range of resistance of riparian vegetation to hydraulic forces.

The normal range of annual flows falls well below bankfull discharge throughout the study area in most years (Tables 3.3, 3.4, and 3.5). Channel scour and bank retreat are not anticipated to greatly affect riparian vegetation. On the contrary, the stability of channel and floodplain vegetation resulting from reduced hydraulic variability is more likely to promote age-dependent vegetation succession (e.g., alder-dominated shoreline in subreach 1A) and limit the extent of new recolonization sites (exposed bars and floodplains) to the more narrow active channel along the low-flow channel. In subreaches 1 and 3, continuous open water, created by a relatively uniform summer base flow, appears to be the primary factor preventing encroachment of woody vegetation into the active channel, in contrast to intermittent subreaches.

Frequency of Floodplain Inundation

Analyses contained in Chapters 3 and 4 demonstrate that changes in two physical processes have significantly altered the relationship of channel flow to floodplain area: channel incision and reduced frequency of bankfull flow. Most of the cross sections evaluated (Tables 4.4 and 4.5) over a time sequence revealed degradation of at least several feet and sometimes as much as 24 feet. Aggradation occurred at some sections but was less common. Channel incision generally increases the cross sectional area of the channel; greater discharge is therefore needed to reach bankfull flow stage and inundate adjacent floodplains where riparian vegetation is commonly found.

The combined effects of the flood control bypass system and flood attentuation and storage in the upstream reservoirs have resulted in significant reductions in both annual and spring flow discharge at 2- to 10-year recurrence intervals (Table 3.1 and 3.2). Upstream of the San Luis Refuge (Mariposa Slough), computed bankfull discharge for most sections varies from 2,000 to 6,000 cfs, which is generally less than the 5–10 year exceedance flow under existing flood operations of the reservoir and bypass system. The probability of overland flow beyond the natural channel banks measurably increases in subreach 5, which is downstream of bypass and eastside tributary inflow. The consequence of reduced floodplain inundation frequency, depth, and duration is a significant reduction in the availability of land area for riparian vegetation to become established on new surfaces through overland seed dispersal or rewetting of secondary channels, sloughs, and ponded depressions. (See “Limited Seed Sources and Dispersal”, below).

Less inundation of San Joaquin River floodplains may have other indirect consequences that limit riparian vegetation. Overland flooding removes surface thatch and upland plants and seed at the same time a new layer of moist silt and sand is deposited, which helps create favorable germination sites for sunlight-dependent riparian species. Winter and spring flow in secondary channels on the west side of subreaches 4 and 5 may also reduce soil salinity and surface concentrations of boron through erosion, burial, or dilution to levels tolerated by riparian species. Within designated floodways along the river, the lower probability (risk) of flows exceeding bankfull stage may have inadvertently encouraged encroachment of agricultural fields and local levees onto floodplain surfaces previously occupied by riparian woodland or oak savannah, particularly in subreaches 1B and 4B. Once developed for commercial uses, floodplain sites are unlikely to be returned to a natural state unless the cost of flood-damage remediation exceeds economic yield.

Intermittent Flow

Riparian vegetation, including mature cottonwood forest, occurs on both perennial and intermittent streams throughout the southwest and in arid regions of California. Where surface flow is interrupted, subterranean underflow or water tables within the deep root zone of riparian trees and shrubs can sustain vegetation through the latter part of the growing season. Intermittent flow conditions on the San Joaquin River occur in most of subreach 2 (RM 229 to approximately RM 208; the lower part receives backwater from Mendota Pool), and much of subreach 4A and 4B, depending on the inflow of local tailwater between Sack Dam (RM 182) and the confluence with Mariposa Slough (RM 147). There is no base flow requirement below Sack Dam and only 5 cfs is required at Gravelly Ford; the base flow at Gravelly Ford does not extend far downstream because of the porous bed substrate and high rate of percolation.

The absence of predictable flow in subreaches 2 and 4 coincides with a pattern of sparse, patchy, or discontinuous vegetation and a paucity of young growth in the active channel of subreach 2. However, survival of established riparian vegetation does not appear to be affected by intermittent flow in subreach 4, where full-canopied riparian scrub and forest occur in broken stands and ponds rimmed by small areas of marsh vegetation are present within the channel. This subreach is also reported to have shallow groundwater within 5 to 10 feet of the surface, and the water table may be exposed in places above the channel thalweg elevation. (See Plate 58 and the discussion of groundwater in the following section.) Extensive agricultural irrigation during the dry season close to the channel may also help sustain streamside plants. Soil moisture-holding capacity is higher in this subreach because of the larger fraction of fine sediment (silt and clay) in valley floodplain soils, compared to subreach 1 and 2.

Depth to Groundwater

Figures 5.1 and 5.2 show regional groundwater contours in the study area from Friant to Sand Slough in the spring of 1976 and 1986 (U.S. Bureau of Reclamation 1976, 1986). A steep gradient in the downward slope of groundwater along the San Joaquin

River is evident in the vicinity of Gravelly Ford, indicating a high rate of percolation of flow into the river bed. Groundwater contours form a mound under the river upstream of this location and are generally parallel to the river valley below Mendota Pool. Figure 5.3 shows a map of average depth to shallow groundwater (0 to 20 feet below the surface) west of and adjacent to the San Joaquin River in 1987 from above Mendota Pool to the Merced River (Swain 1990). Downstream of Mendota Pool to the Merced confluence, the average depth of the shallow water table was within 5 feet of the surface, except for in two areas near Firebaugh and Highway 152, where the depth varied 5–10 feet. Water year 1987 followed a wetter than normal water year. Data mapped on these figures indicate that the depth to the water table does not appear to be a major limiting factor for riparian vegetation once it is established in subreaches 3, 4, and 5. Furthermore, during field surveys, canopy wilting, tip dieback, and large-scale mortality of mature tree groves, indicators of water table drawdown below the root zone, was not observed in subreaches 3, 4, and 5.

In subreaches 1 and 2, groundwater contours in spring 1986 are generally near the channel bed elevation above Gravelly Ford, but plummet to 20–30 feet below the bed from Gravelly Ford to the lowermost subreach upstream of Mendota Pool. Contours fall 70 vertical feet between RM 240 and RM 220 (3.5 feet per mile) near Chowchilla Bypass, but drop only 10 vertical feet over 30 river miles (0.33 feet per mile) from RM 220 to RM 190 below Firebaugh. Riparian vegetation appears to be potentially limited by the availability of shallow groundwater in subreach 2 but not in the other subreaches. However, terrace and floodplain surfaces and abandoned secondary channels may be positioned well above the active channel in subreaches where channel incision has occurred (note changes in thalweg elevations, Table 4.4 and 4.5) in combination with reduced average discharge and stage. Natural regeneration at these sites may be limited by depth to the water table, although deep-rooted old-growth valley oak, sycamore, and other mature tree species may be present and appear healthy.

Salinity and Soil Suitability

Figures 5.4 and 5.5 show generalized maps of boron concentrations and EC in shallow groundwater (0 to 20 feet below the surface) west of and adjacent to the San Joaquin River in 1987 from above Mendota Pool to the Merced River (Swain 1990). In general, salt and boron concentrations are much lower in soils and groundwater influx from the east side of the San Joaquin River valley (Verrill pers. comm.). Boron concentrations averaged 8–16 ppm in subreach 3 above Firebaugh, less than 2 ppm below Firebaugh through subreach 4, and 2–4 ppm in subreach 5 and part of subreach 4B. Boron, a micronutrient important to plants, can adversely affect plant growth and vigor at levels exceeding 2 ppm. However, a high degree of local variability of soil and groundwater quality may be expected, and generalized data cannot substitute for site-specific measurements (Verrill pers. comm.).

A similar pattern is shown for EC, at 5,000–10,000 uS/cm (microSiemens per centimeter) in upper subreach 3, less than 2,500 in lower subreach 3 through upper subreach 4B, and 5,000–10,000 in subreach 5 and lower subreach 4B. The effects of EC greater than 2,500 on plant growth is of concern (Verrill pers. comm.), with adverse effects on seed germination and seedling survival in riparian plants. A USGS study of groundwater inflow quantity and quality in the San Joaquin River between Hills Ferry and Patterson (Phillips et al. 1991) found EC levels of 3,400 uS/cm in shallow groundwater at the Newman gage below Merced River but only 600 uS/cm in flood water. Their study found that relatively high pumping rates east of the river induce groundwater flow from west to east and cause higher levels of salinity concentration from groundwater entering the San Joaquin River. (In 1988/1989, the third year of a drought, 76% of river discharge was attributable to groundwater inflow.)

The California Regional Water Quality Control Board drilled or sampled several wells in the vicinity of Mendota in the early 1990s and collected data on the quality of groundwater. Data from nine observation wells indicated a median EC of 5,600 μmho/cm, ranging between 1,300 and 9,600; median total dissolved solids was 3,500 mg/l, ranging from 800 to over 6,000. Boron concentrations in groundwater had a median of over 2,000 μg/l, ranging from 1,300 to 5,000. These levels are considered potentially harmful to most plants if the well water is used for irrigation purposes (California Regional Water Quality Control Board 1988).

Boron and EC levels in soils and shallow groundwater are potentially a limiting factor for riparian vegetation in upper subreach 3, lower subreach 4B, and subreach 5. Concentration of salts in surface soil deposits is most likely to occur where the upper surface of the water table is exposed to capillary rise and evaporation because of the topography. Salt efflorescence was observed at the upper edge of moist banks and on low bars and isolated depressions or swales in subreach 5 and lower subreach 4B, often associated with scattered halophytes and an overall lack of vegetation cover within the affected elevation band. Young growth of riparian vegetation is sporadic to uncommon in these two subreaches; the pattern of remaining riparian vegetation seen on 1993 aerial photographs along the San Joaquin River and secondary channels and sloughs is similar to the patchy distribution in 1938 photos, but there is less total cover.

Flood management and reservoir flood storage have resulted in a lower frequency and duration of out-of-bank flows (Tables 3.1 and 3.2). Lack of periodic floodplain inundation may have reduced the process of dilution of naturally saline shallow groundwater in tributary swales and depressions and erosion of saline silt crusts that form on banks and bars in the channel of subreaches 4 and 5. However, actual measurements of these parameters at riparian sites are needed to verify the extent of this limiting factor.

In-Channel Sand and Gravel Mining

Sustained commercial mining of sand and gravel does not occur on the San Joaquin River below subreach 1 because of low market demand and relatively high transport and handling costs. However, excavation of sand in the river for private use by local ranches occurs at many sites in subreach 2, primarily upstream of Chowchilla Bypass. LSJLD does not engage in sand removal activity, except occasionally to remove deposits from the sedimentation basin in Chowchilla Bypass below the bifurcation dam. Sand is used by local ranches (primarily vineyards and orchards) for elevating local farm roads and other uses (Hill pers. comm.). Excavation takes place both in shallow pits and by bar skimming operations, with sand stockpiled in large mounds inside the levees on low floodplains. Existing riparian vegetation in subreach 2 represents very little cover, so not much established vegetation is affected by sand removal. However, the potential for new stands to establish is affected in proportion to the area skimmed. This subreach supported the largest observed extent of 1- to 2-year old cottonwood seedlings and saplings found in the entire study area. Seedlings and small saplings were found on sand and pea gravel bars in long linear bands at the margins of the low flow channel.

Agricultural Conversion of Low Floodplains

As stated earlier, extensive agricultural reclamation and local levee and canal construction along the San Joaquin River had occurred by 1938. In the following decades, annual cropland and more natural rangeland topography was converted over large expanses of farmland to vineyards and orchards. Most of the recent conversion did not directly affect (remove) riparian habitat. However, there appears to be a gradual and ongoing trend of replacement of riparian floodplains with new vineyards and orchards on lower-elevation sites. Many of these sites experienced damage from river scour and sand deposition in the 1997 flood and perhaps in 1998 as well.

Based on comparison of aerial photographs from different years, additional mature riparian vegetation appears to have been recently removed from lower floodplains and bar surfaces to allow encroachment of perennial crops. The presence of commercial agriculture may preclude future colonization of these lower floodplain sites for riparian habitat and may increase the future demand for flood damage reduction and bank protection at the expense of riparian habitat. Floodplain encroachment of perennial crops primarily occurs in subreaches 1A and 2. Expansion of local levees and land leveling within the historic meander belt of subreach 2 has also replaced floodplain and oxbow vegetation with annual and perennial crops and has prevented riparian recolonization of the low-relief topography.

Other Local Influences on Vegetation Pattern

Floodway Management

Vegetation removal for floodway management within the active channel is performed infrequently on a limited scale by LSJLD. Under an existing streambed alteration agreement with DFG (Section 1601 of the California Fish & Game Code), which is renewed annually, spot treatment of channel constrictions created by dense vegetation, primarily sandbar willow shrubs and giant reed (*Arundo donax*, also known as false bamboo), is performed at critical sites using manual labor; no heavy equipment is allowed in the channel. In 1990, an extensive channel clearing and snagging project was proposed by the Corps and LSJLD to remove vegetation and sediment on channel bars, totaling 323 acres of vegetation clearing and 265 acres of sand bar removal on 51 river miles between Mendota Dam and Sand Slough and Mariposa Bypass to Highway 165. However, the project was abandoned and the application for a permit under Section 404 of the federal Clean Water Act was withdrawn because of the high costs, environmental permitting issues, and resource agency concerns (Hill pers. comm.).

The field and aerial surveys conducted in 1997 found no recent evidence of significant vegetation removal for floodway management in the study area other than incaand j(r res of sad baskev)13commingedon removaitabridnag1

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Herbivory

Most of the study area is not subject to livestock grazing in the riparian zone. Light grazing by cattle was observed during the field surveys in portions of subreach 5, but the effect on riparian vegetation appeared negligible at the time. However, browsing livestock could affect the survival or growth rate of new stands of willow that may have colonized moist bars along the channel if stocking rates are high and livestock use extends over most of the growing season. The extent and seasonal use of the riparian corridor in subreaches 4 and 5 by grazing livestock is unknown, but other subreaches appear to be unaffected. The Bear Creek Unit of the San Luis National Wildlife Refuge complex was heavily grazed for decades prior to being purchased by USFWS; most grazing ceased two to four years ago (Frazer pers. comm.). Distinct browse lines are visible on the canopy of mature trees in the subreach of the river adjoining the refuge.

Signs of beaver populations (stick lodges, felled and girdled trees) were observed in the field primarily in subreaches 3 and 5, which sustain perennial flow, but not in subreaches 1B, 2, or 4. Beavers are unlikely to occupy subreaches with long periods of little or no flow or without an adequate supply of young-growth riparian plants for food. In areas where the signs of beavers were observed, the primary effect appeared to be the selective harvesting (removal) near the low-flow channel of cottonwood, a species they seem to prefer over others as a food source. The flood of 1997 may have temporarily reduced the populations of beaver on the San Joaquin River in areas where the depth and velocity of flow in confined channels unearthed lodges and other refuge. Subreach 3, with a predictable perennial base flow and infrequent high flows, provides stable habitat for beavers and plentiful food supply. The low proportion of mature cottonwood trees relative to other species near the low-flow channel in subreach 3 could be affected by beaver populations.

Limited Seed Sources and Dispersal

For favorable colonization sites to be occupied by riparian plants, there must first be an upstream or upwind source of seed and a suitable dispersal mechanism to disseminate the seed. Many riparian species disseminate seed by both wind and water during a concentrated spring release, typically during March, April, or May (cottonwood, willow, and sycamore) or more gradually in late fall/early winter (alder, ash, and box elder). The timing of dispersal and spring germination can vary from year to year, but seedlings and saplings are generally observed in lines corresponding to spring water levels and on moist, unshaded, often bare soil sites.

An adequate seed source does not appear to be a limiting factor on the San Joaquin River. Subreach 2 is the area most devoid of riparian vegetation of any age class, yet it supported the largest concentration and extent of cottonwood seedlings in the fall of 1997 (an unusually wet year with uncharacteristic sustained flow in subreach 2). Subreaches 4B and 5 have patchy, often sparse, woody vegetation cover, but willow seedlings and saplings were encountered in dense crops on moist, low bars and in backwater sloughs distant from the nearest seed-bearing trees. Seed dispersal may be limited in normal and dry years in subreaches lacking flow during spring months or where seed release is followed by a gradual rise in managed spring flows to meet increasing irrigation demand, causing a rise in stage pulses. Subreaches most affected by inadequate spring dispersal flows are 2, lower 4A, and upper 4B.

Probable Future Condition of Riparian Habitat

Table 5.1 speculates on the future condition of riparian vegetation in the study area, based on apparent trends observed in the field and trends of change in vegetation cover and land use described in the companion study on historical riparian habitat conditions (Jones & Stokes Associates 1998); data in the table are based on the assumption that there will be no changes in the current pattern of in-channel or adjacent land use or managed river hydrology. The combined interaction of constraints on the extent and succession of riparian vegetation described in this section was also considered. Restoration projects, changes in river management and flood control operation, and changes in land use intensity may affect the trends described or the rate and magnitude of change in the riparian corridor.